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# Simulation of a Wide-Band Low-Energy Neutrino Beam for Long Baseline Experiments

*using GNUMI*

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(W&M)

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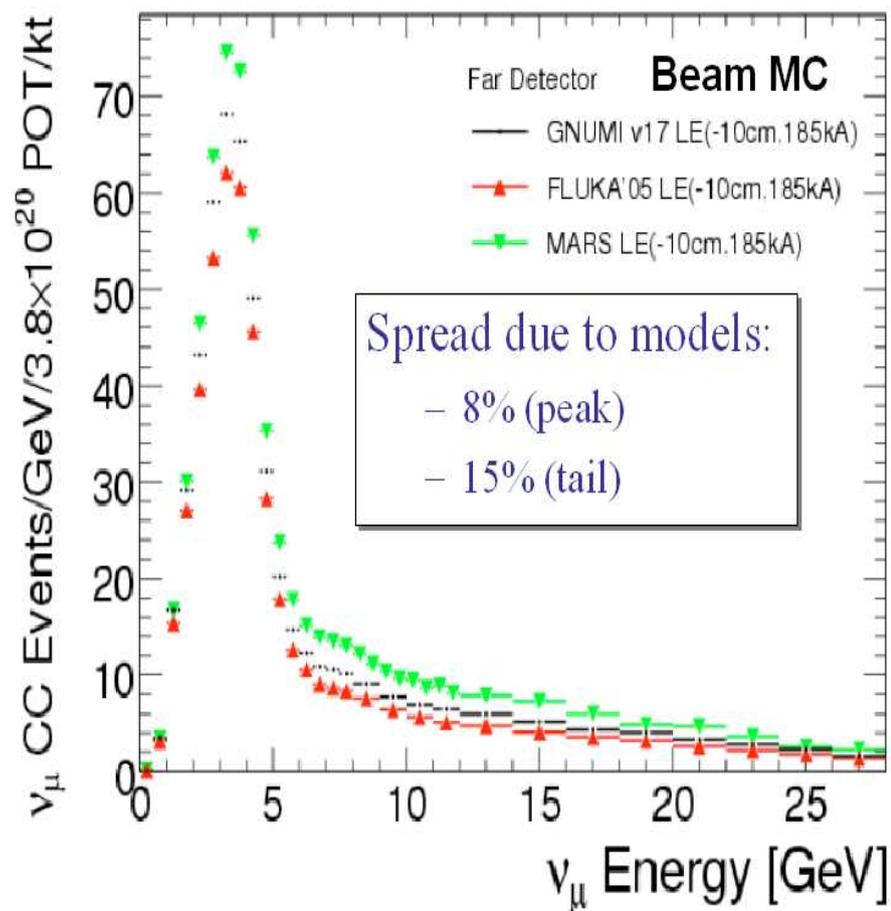
# Whats GNUMI?

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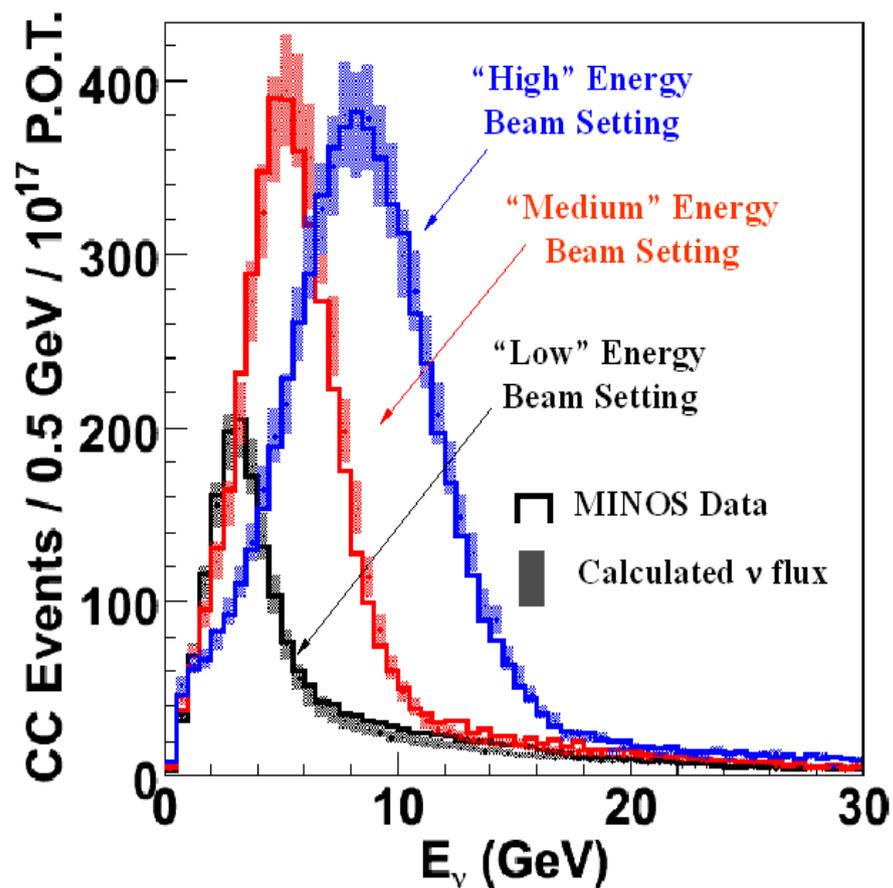
- Simulation of the NuMI beamline using GEANT v3.x
- The default uses built in GEANT-FLUKA for hadroproduction from a given target
- Can use independent programs, like FLUKA 05, to produce hadron spectra and then use GNUMI to swim hadrons through horns, decay tunnel...etc.



# How well does it work?



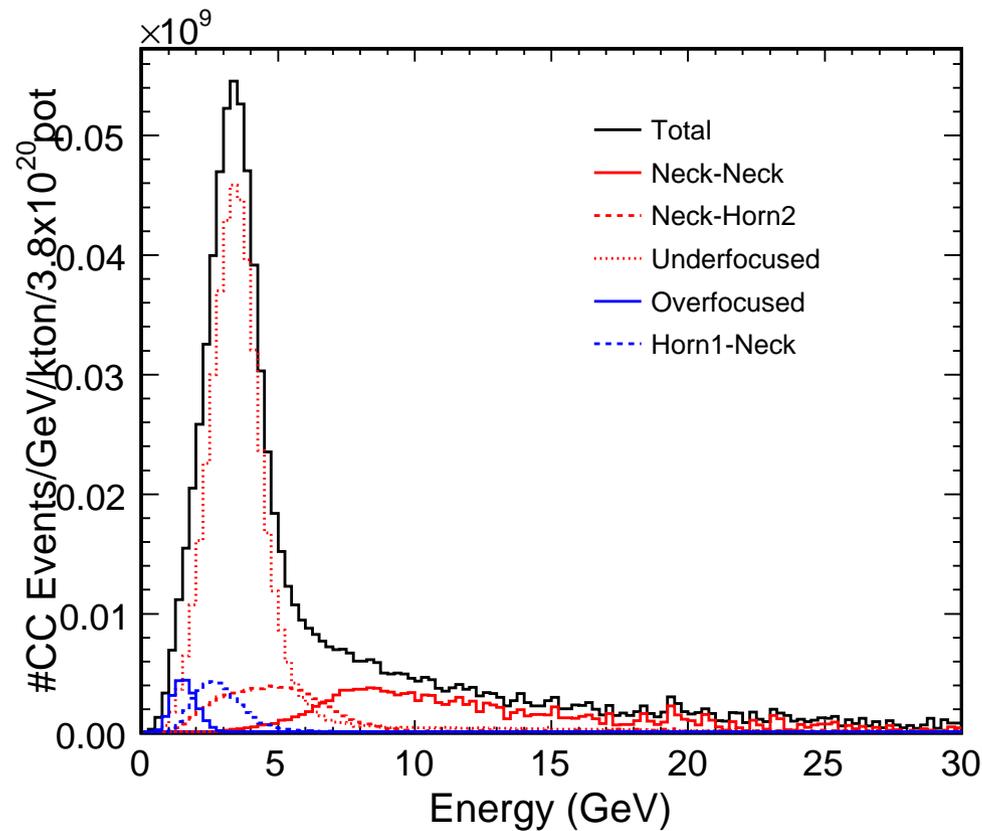
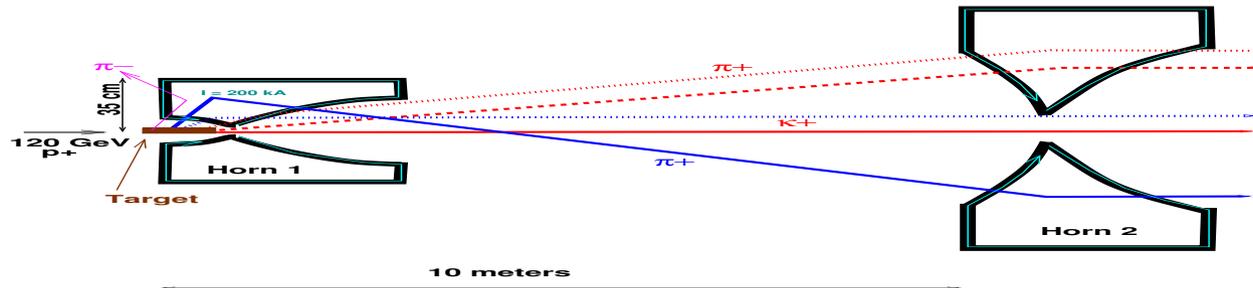
GFLUKA/FLUKA05/MARS



ND spectrum vs FLUKA05, POT normalized



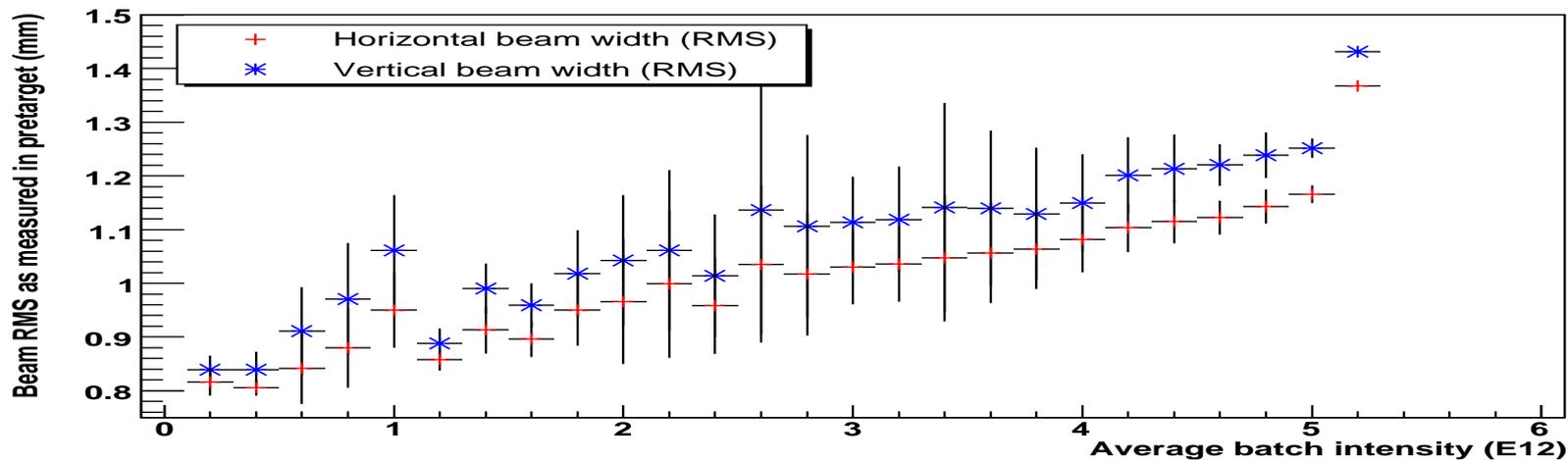
# Focusing details using GNUMI



# NuMI/WBLE differences

Component	NuMI	WBLE
Target:	rectangle, 6.4mmx20mmx1m	tube, r=6mm, l=0.6m
	graphite	graphite
Horns:	2	2
	2 paraboloids/horn	multi cylinders/horn
	Al	Al
Target shielding	upstream baffle	no baffle
	cement blocks	no blocks
Beam:	$\sigma_x = 1.1\text{mm}, \sigma_y = 1.25\text{mm}$	$\sigma_x = 1.5\text{mm}, \sigma_y = 1.5\text{mm}$

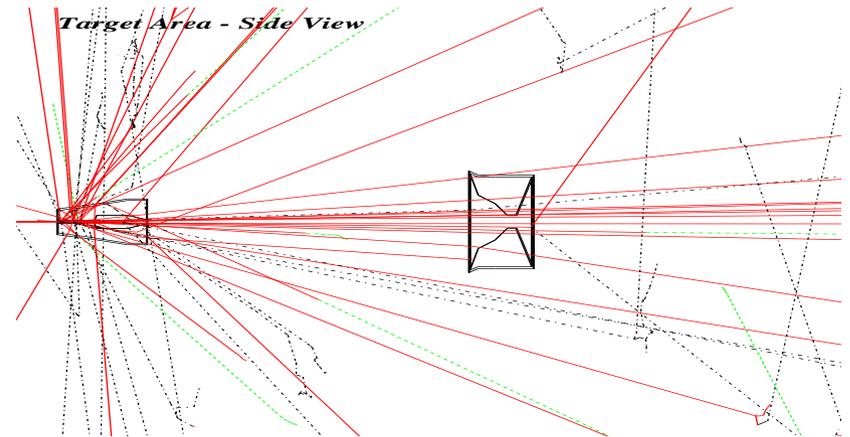
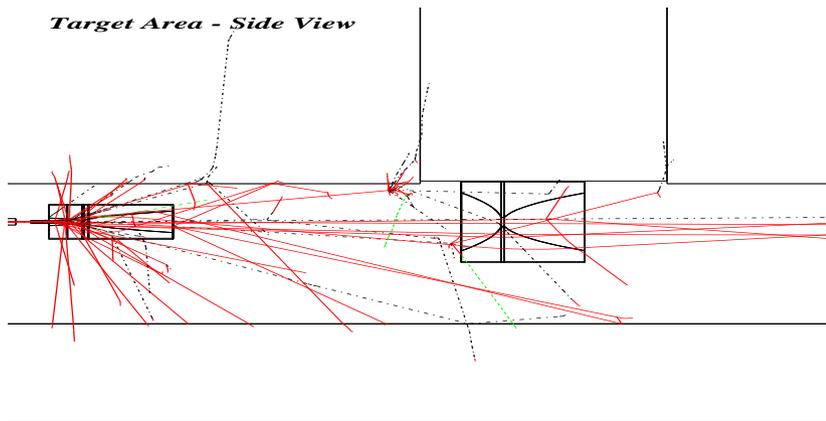
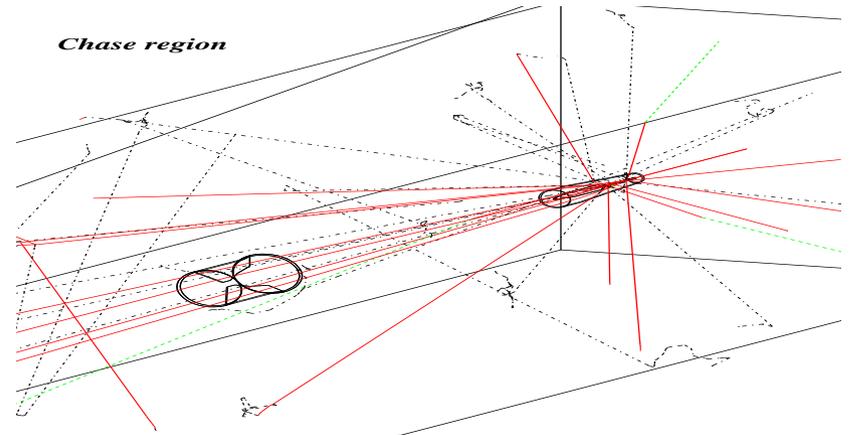
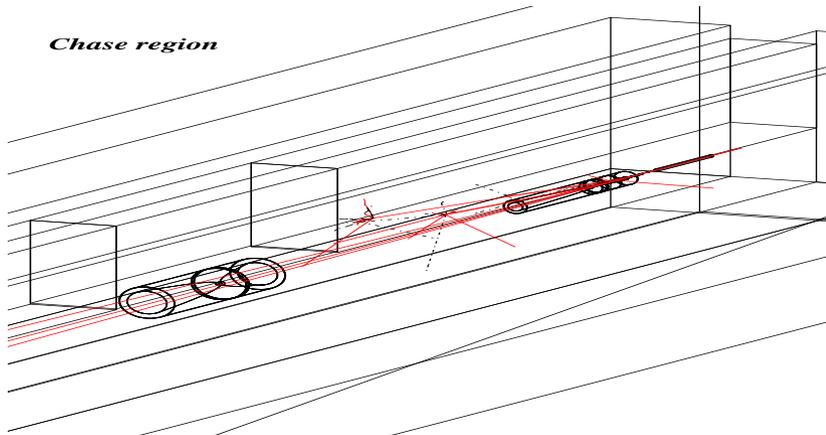
NuMI beam profiles versus average batch intensity



# Target region simulation

NuMI horns/target with 120 GeV p+

WBLE horns/target with 120 GeV p+

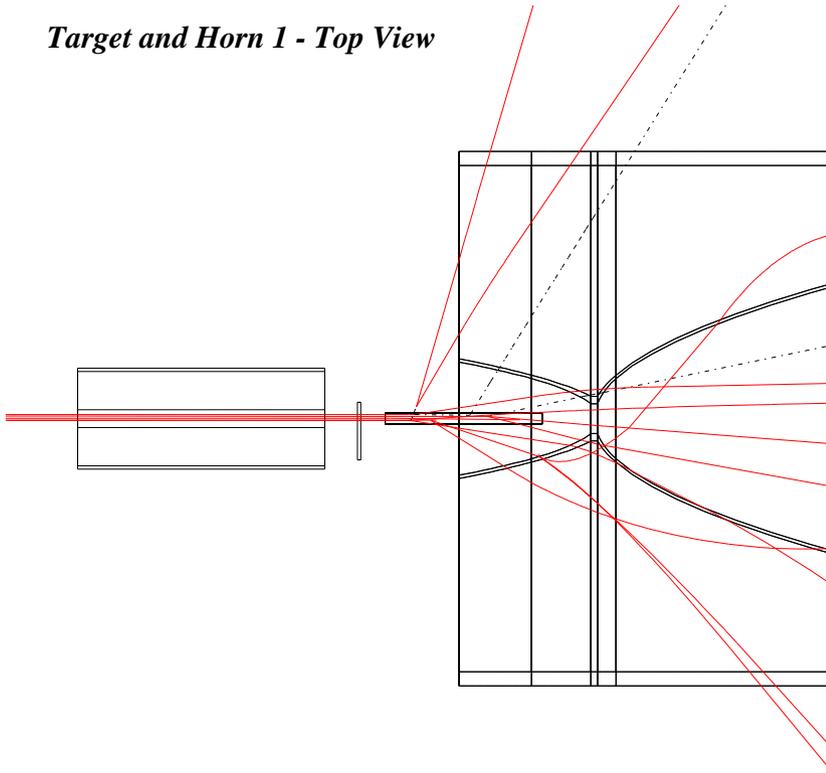


# Horn details

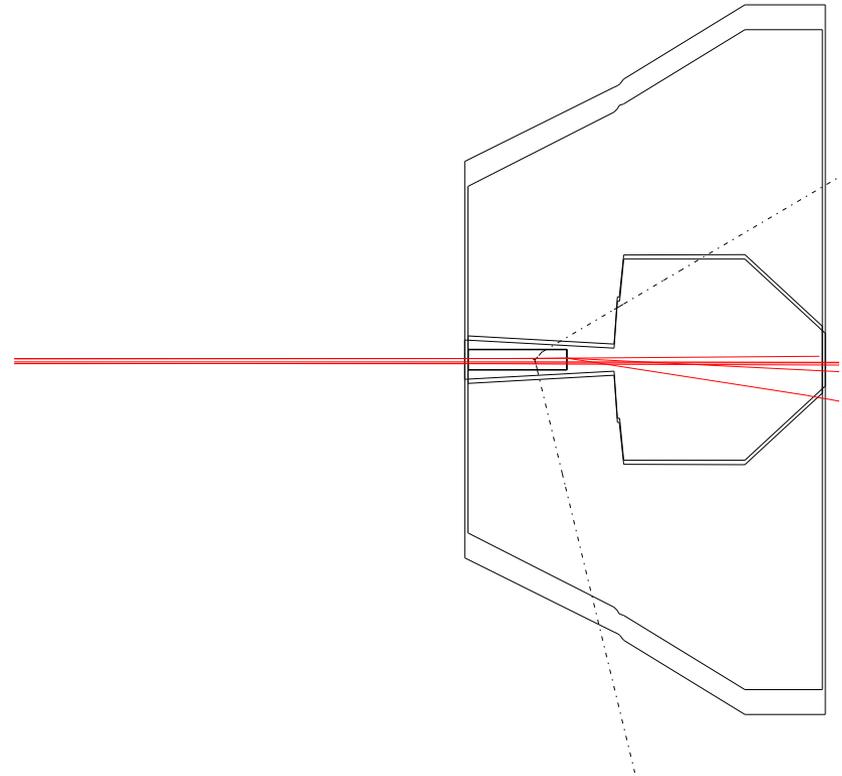
NuMI horns/target with 120 GeV p+

WBLE horns/target with 120 GeV p+

*Target and Horn 1 - Top View*

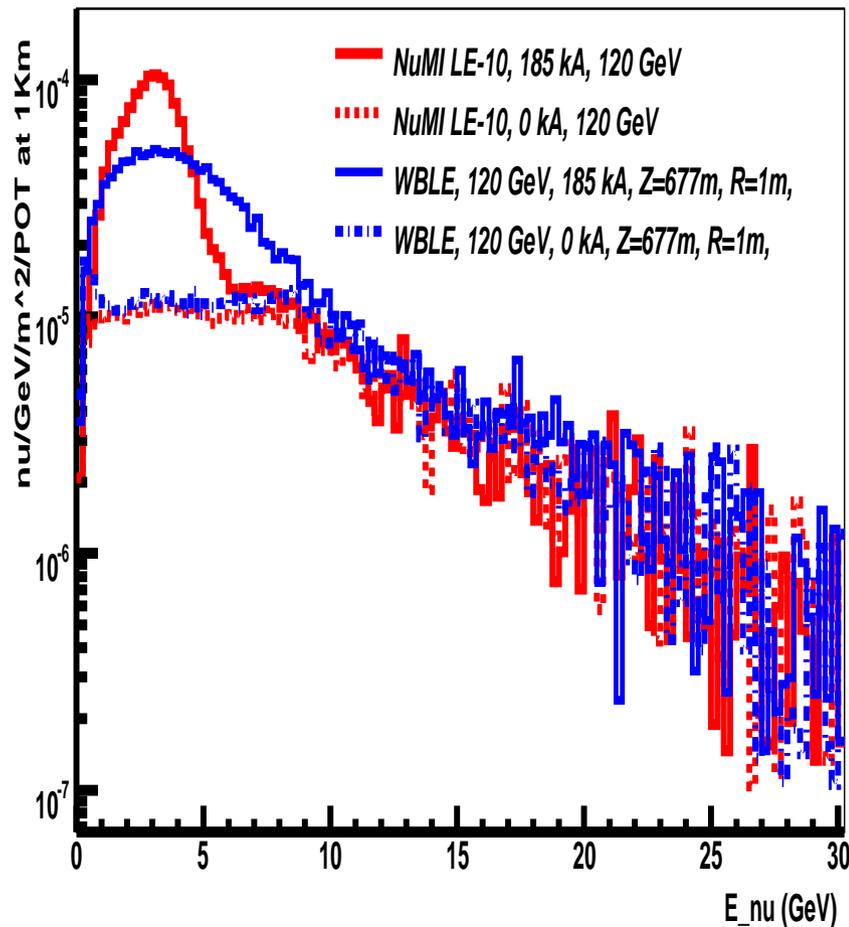


*Target and Horn 1 - Top View*



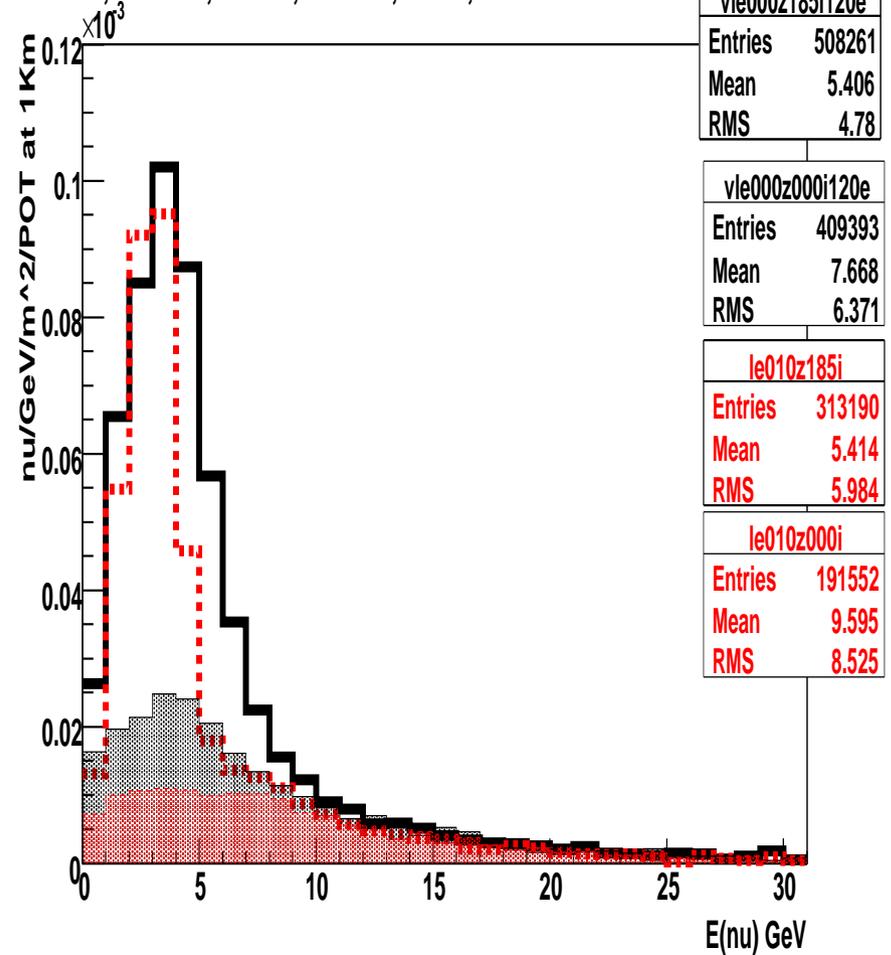
# NuMI LE vs WBLE with GFLUKA

NuMI LE-10, 185 kA, 120 GeV



1m radius decay pipe

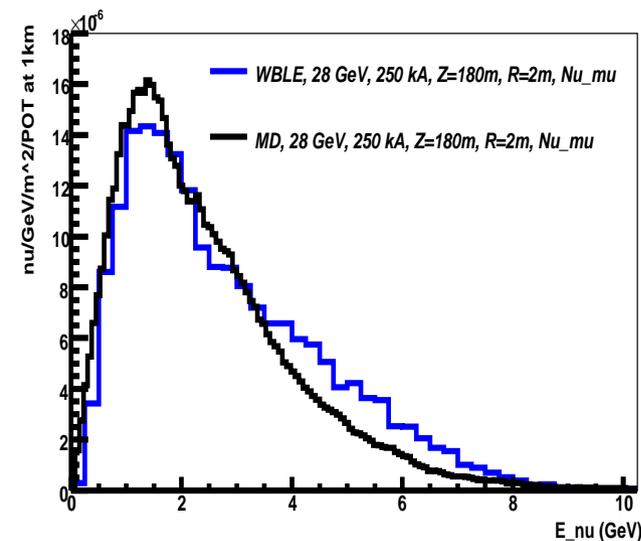
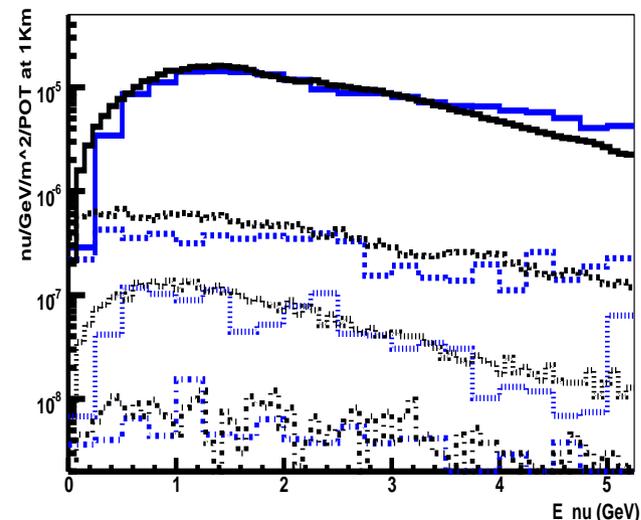
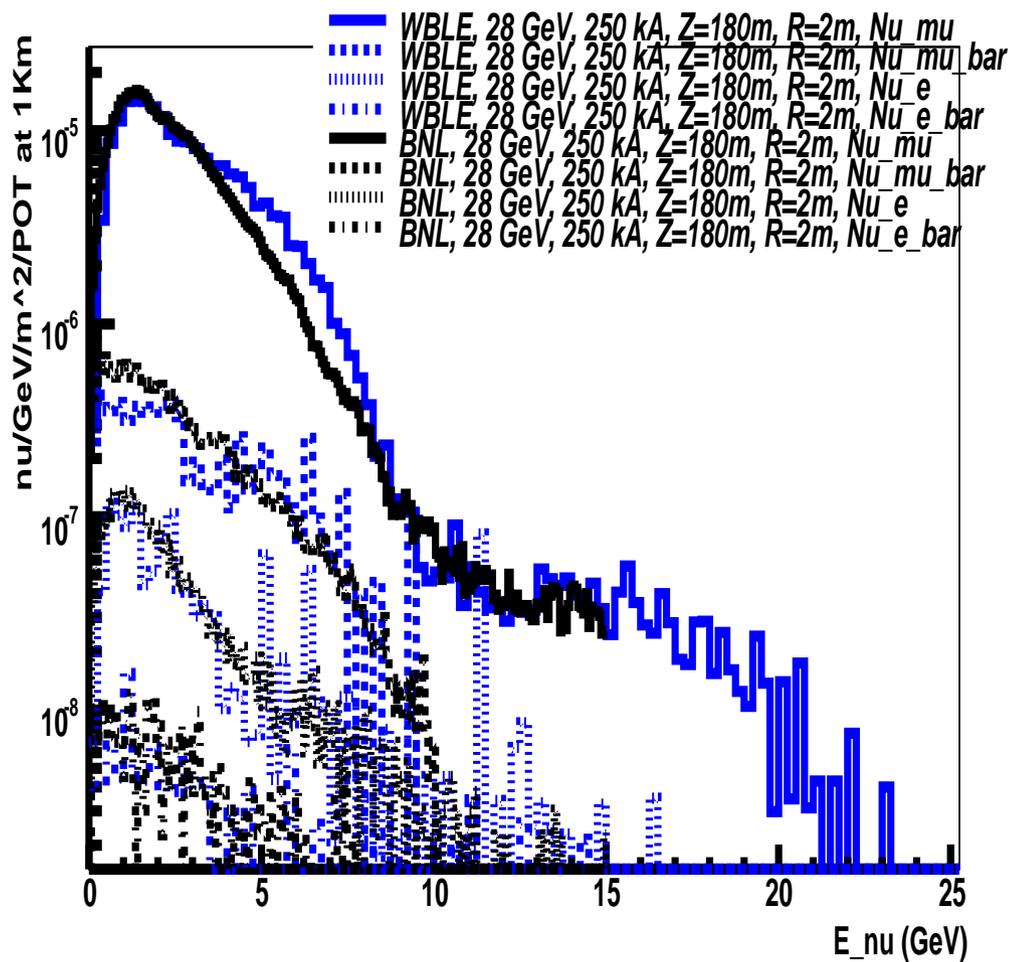
WBLE, 120 GeV, 185 kA, Z=677m, R=2m,



increase to 2m radius

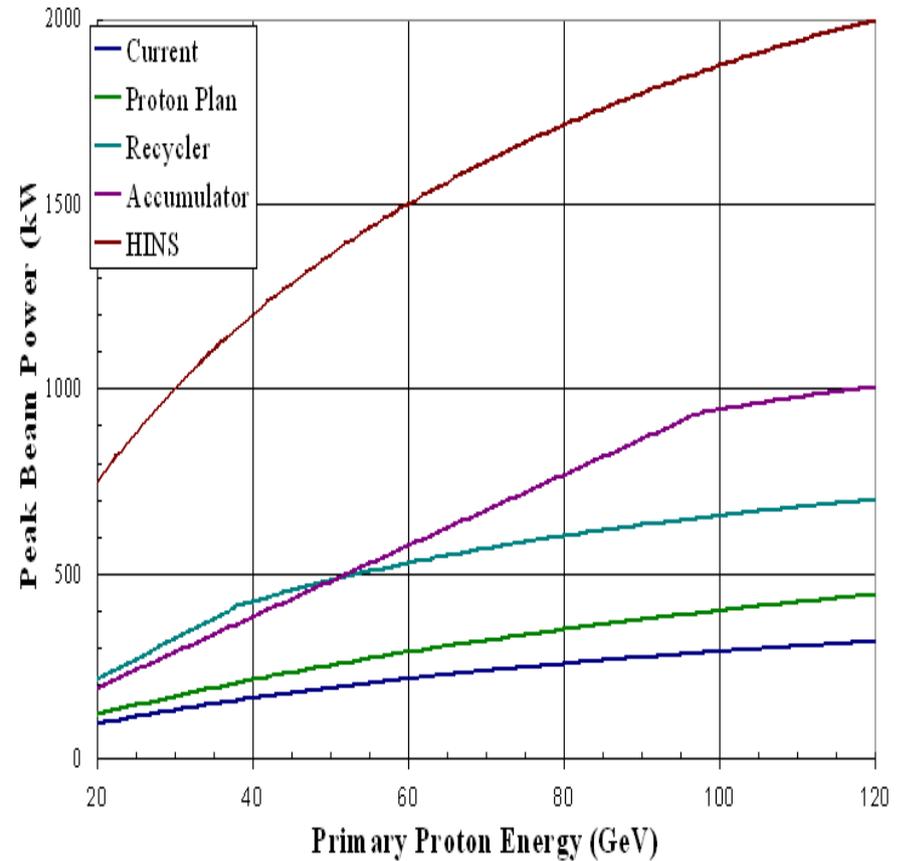
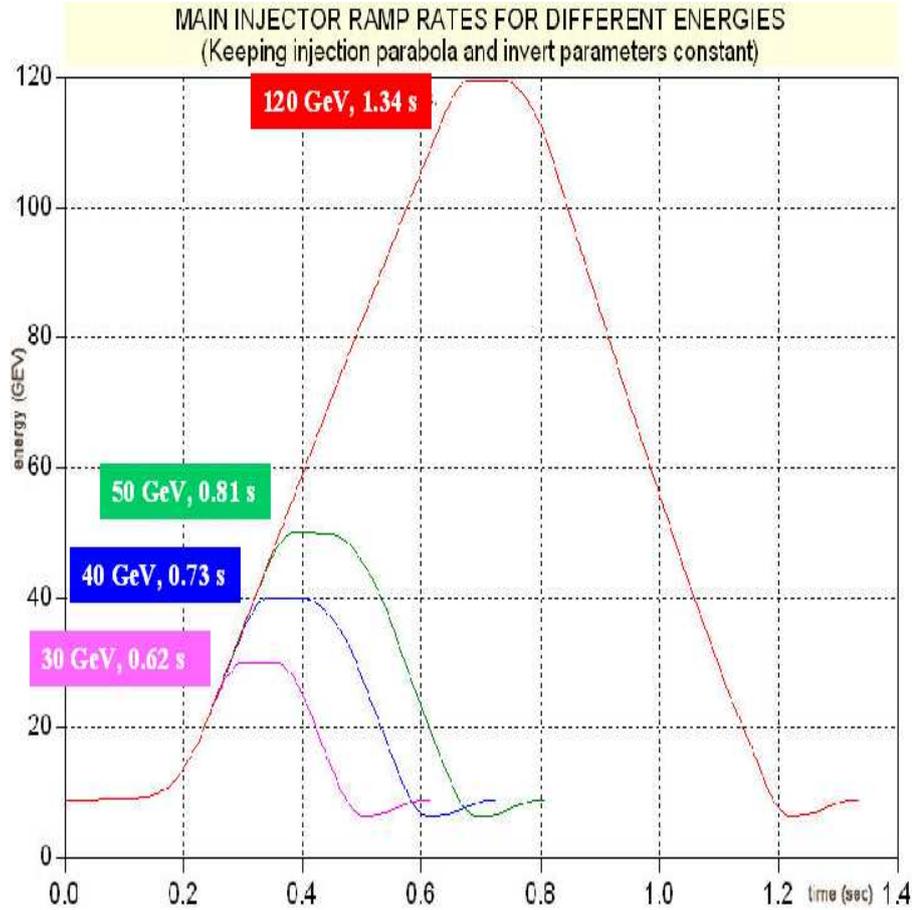


# WBLE/BNL-beam comparison



# Optimization params: E & Power

Bob Zwaska (FNAL)



# Optimization params: Decay Pipe

Greg Bock (FNAL)

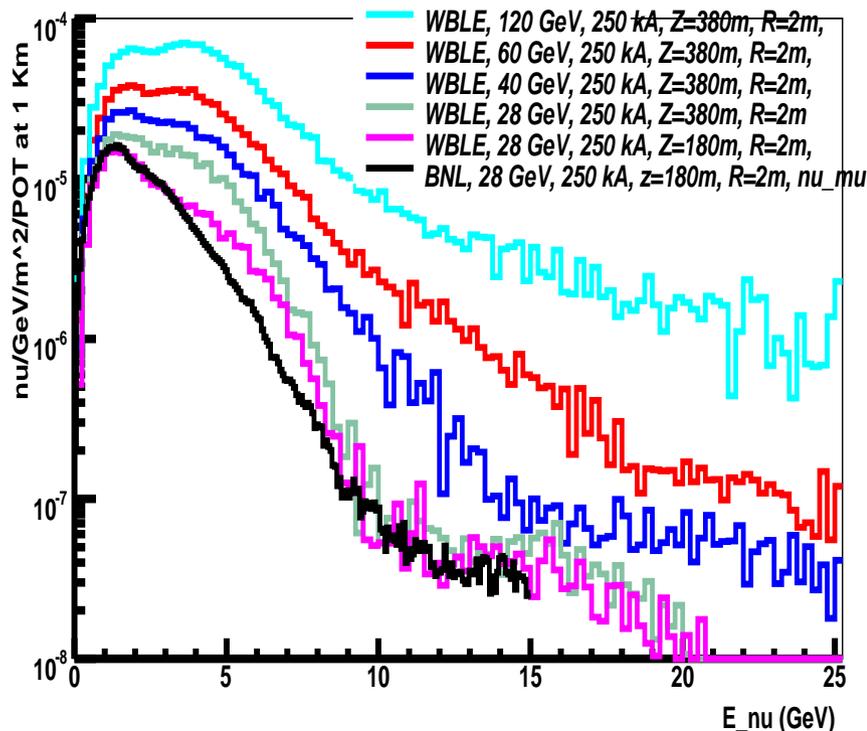




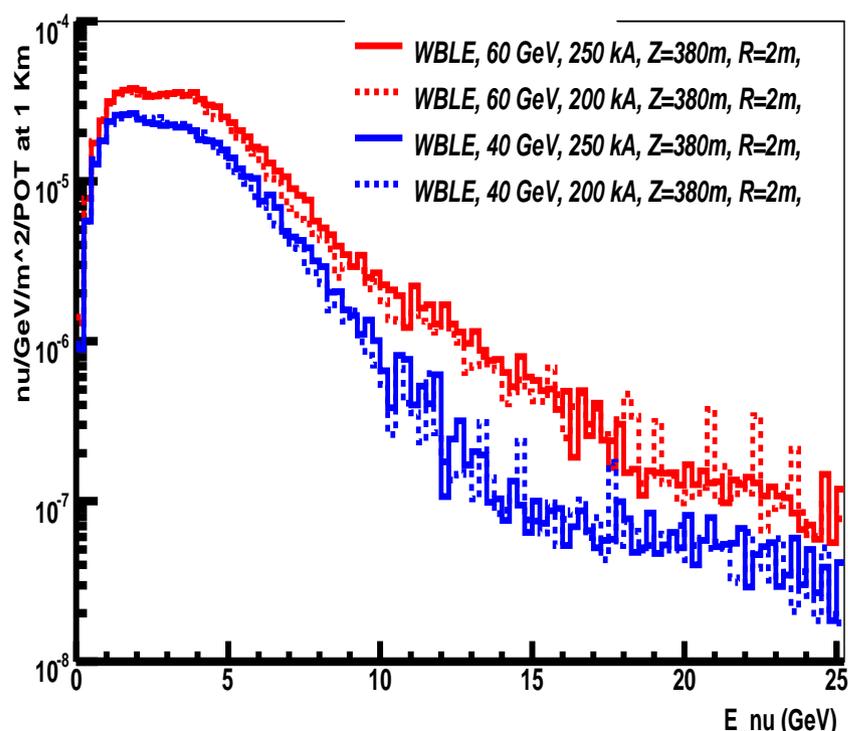
# WBLE-optimization

The current NuMI tunnel encompassing the decay pipe is 3.3 m in radius  $\Rightarrow$  can accommodate a 2m radius decay pipe. **Siting restrictions  $\Rightarrow$  decay pipe is  $\leq$  400 m in length**

WBLE, 60 GeV, 250 kA, Z=380m, R=2m,



WBLE, 60 GeV, 250 kA, Z=380m, R=2m,



# Optimization variables

Beam Scenario	Peak $E$ (Flux at 1km) $\nu/(\text{GeV}\cdot\text{m}^2\cdot\text{POT})$	$E$ at 50% Peak flux	$E$ at 10 % Peak Flux	Flux $\begin{matrix} \leq 5 \\ > 5 \end{matrix}$ GeV	Purity peak	Purity Total
NuMI LE-10	3.1 GeV ( $1 \times 10^{-4}$ )	4.3 GeV	8 GeV	2.7 GeV		92% $\nu_\mu$
WBLE 60 GeV	1.9 ( $3.6 \times 10^{-5}$ )	5.5	8.3	3.2		92% $\nu_\mu$
WBLE 40 GeV	1.6 ( $2.6 \times 10^{-5}$ )	5.0	7.8	4.2		94% $\nu_\mu$
WBLE 30 GeV	1.4 ( $1.9 \times 10^{-5}$ )	5.0	7.0	5.5		95% $\nu_\mu$
BNL 28 GeV	1.4 ( $1.6 \times 10^{-5}$ )	3.0	5.5	6.1*		96% $\nu_\mu$



# To Do:

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- Implementation of FLUKA 05 hadroproduction in WBLE.  
**Preliminary implementation of WBLE target geometry.**
- Add shielding to WBLE target region.
- Quantifying optimization criteria for different fluxes
- Horn focusing studies
- Simulate more statistics ( $10^5$  POT/1 hour).
- Obtain fluxes and event rates at 1300 and 1500km
- Use NuMI/MINOS experience to estimate flux uncertainties
- Compute oscillation sensitivities for different beams using GloBES

